REMARKS

In the Office action, the Examiner first objected to claim 14 under 35 C.F.R. §1.75(c) as being of improper form. We respectfully submit that the foregoing amendment fully addresses this objection.

The Examiner rejected claims 1-7, 9-13, 20, 21, 24, 25, and 32-36 under 35 U.S.C. §103(a) as unpatentable over WO 00/17102; claims 1, 2, 7, 9, 11-13, 15, 18-22, 24, 25, 29-34, 36, and 37 under §103(a) as unpatentable over U.S. Patent No. 6,413,487 to Resasco et al. ("Resasco"); claim 8 under §103(a) over WO 00/17102 or Resasco in view of U.S. Patent No. 6,855,376 to Hwang et al. ("Hwang"); claims 4-6, 14, 16, 17, 20, 21, and 24-26 under §103(a) over Resasco in view of U.S. Patent No. 6,967,013 to Someya et al. ("Someya"); and claims 20-29 under §103(a) over WO 00/17102 or Resasco in view of U.S. Patent No. 4,572,813 to Arakawa ("Arakawa").

We have amended claim 1 to include the limitations of claims 7, 8, and 20 as previously presented. In addition to having basis in these claims as originally filed, the amendment to claim 1 is further supported at least at page 3, lines 4 to 13; page 4, lines 1 to 12; and page 6, lines 17 to 20 of the specification. The amendment to claim 22 is supported by the claims as originally filed and is further supported at least at page 6, line 29 to page 7, line 1 of the specification.

For the reasons that follow, we respectfully submit that there is nothing in the prior art that would teach or suggest to one of skill in the art, at the time the invention was made, the empirical finding that the method recited in amended claim 1 would be capable of producing aligned carbon nanostructures. It is noted that the Examiner's rejection of original claim 8, the limitations of which are now recited in claim 1, relies on a combination of WO 00/17102, Resasco, and Hwang. We submit that neither WO 00/17102 nor Resasco is sufficient to render obvious claim 1 as originally filed, much less as amended; and that Hwang, in any case, is neither properly combinable with WO 00/17102 or Resasco nor sufficient to render obvious the additional limitations of claim 8 as originally filed.

WO 00/17102 describes a method of producing predominantly single-walled carbon nanotubes with a transition metal catalyst supported on an inert surface and contacted with a suitable feedstock. The support may be in the form of spheres, irregularly shaped particles or flakes and may range in size from about 10 nm to centimeters. WO 00/17102 thus specifies a wide range of shapes and sizes for the support material, suggesting that the actual shape of the particle is of limited importance. While WO 00/17102 teaches that single-walled nanotubes may be produced in separate or aligned form, due to dispersion of transition metal clusters (page 9, lines 24 to 30), there is nothing in this reference that would allow empirical prediction that the support particle shape or size has any influence upon this. There is thus nothing in WO 00/17102 that would encourage one of skill in the art to investigate substrate particles with any specific radius of curvature, much less teach or even suggest that the support material should have smooth faces with radii of curvature of more than 1 μm with length and breadth as specified in claim 1. Furthermore, WO 00/17102 would not suggest the empirical finding that the particles used in the process of the present invention produce aligned nanostructures. Even apart from the deposition techniques now recited in claim 1, the claim is thus patentable over WO 00/17102, and accordingly all claims depending thereon are also patentable.

Resasco provides a process for continuous catalytic production of carbon nanotubes. The catalytic particles comprise solid support material impregnated with a metallic catalyst and calcined and processed into a pellet form, with processing into the pellet form occurring before or after impregnation of the support material with the catalyst. Resasco does not make any mention of what dimensions these pellets should have. It does, however, indicate in embodiments that the support material is subject to dissolution by treatment with a base or an acid (column 4, lines 45-54) and is then recovered by precipitation (column 5, lines 14-16). As illustrated in Figure 1 of Resasco, this precipitated material is then topped up with fresh support material, impregnated with a metal catalyst and then processed once more into pellet form. The pellets produced by such a process would be expected to be formed from pelletized powder of the solid support impregnated with the metallic catalyst throughout the pellet. There is nothing in Resasco suggesting any other type of catalytic particle, much less one with a substantially smooth surface with radii of curvature and dimensions as specified in claim 1 with catalyst

material on the surface. Furthermore, Resasco does not teach methods for production of aligned nanotubes; accordingly, one of skill in the art looking to produce aligned nanotubes, as required by the present claims, would not consider Resasco.

The Examiner recognizes that neither WO 00/17102 nor Resasco teaches the deposition processes now specified in claims 1; for this she cites Hwang. The Hwang patent is directed to a process of direct low-temperature growth of carbon nanotubes on a substrate. The overall process used in Hwang is set out in Figure 1 thereof, and involves forming a metal support layer on a substrate, forming a metal catalyst layer on the support layer, forming a bonding metal layer on the catalyst metal layer and then growing the carbon nanotubes by thermal chemical vapor deposition. The metal support layer and bonding metal layer are both formed from a noble metal. Hwang discloses that the metal of catalyst layer can be formed by vacuum sputterring, chemical vapour deposition, physical vapour deposition, screen printing or electroplating. Hwang does not, however, suggest that any of these techniques will be of any use in depositing the catalyst layer except when it is sandwiched between noble metal support and bonding layers. WO 00/17102 is directed to transition metal catalysts deposited directly on refactory nanoscale support particles (page 8, lines 26 to 28), while Resasco is directed to a pelletized support material impregnated with catalyst. Neither of these systems involves a noble metal support layer or a noble metal bonding layer, and accordingly, one of skill in the art would not combine their teaching with the catalyst layer deposition techniques of Hwang. Indeed, Resasco, which contemplates catalyst throughout the pellet, actually teaches away from the present invention as recited in claim 1, which requires catalyst material deposited onto the surface of already-formed substrate particles by the deposition methods now recited in claim 1.

More generally, as the invention as recited in claim 1 does not involve a noble metal support layer or noble metal bonding layer, Hwang is simply not relevant. Accordingly, Hwang cannot supply what WO 00/17102 and Resasco lack, and claim 1 and its dependents are therefore patentable over this reference — alone or in combination with others.

Someya is cited, inter alia, against original claim 20, the limitations of which now appear in claim 1. Someya discloses a process for producing aligned carbon nanotube film. The substrate in Someya is coated with an element having no catalytic ability, and then the metallic element with catalytic ability is loaded onto the substrate, with exemplified substrates in the form of squares of at least 30 x 30 mm. Although Someya teaches a process for formation of aligned carbon nanotubes, it does not provide empirical teaching in relation to this that can be applied to other prior art to produce aligned nanotubes. Accordingly, one of skill in the art would not combine Someya with the other cited art that lacks the step of coating the substrate with an element having no catalytic ability. There is also nothing in Someya that would suggest the use of finely divided substrate particles as recited in claim 1, or the deposition methods set forth in claim 1. Claim 1 is accordingly inventive over Someya, alone or in combination with other references, as are all of its dependents.

Arakawa is also cited, inter alia, against original claim 20. Arakawa discloses a process for preparing fine carbon fiber in a gaseous-phase reaction. The fibers are prepared by reacting, at the elevated temperature, a mixed gas consisting of a gas of an organic metal compound or compounds and a carrier gas with a gas of a carbon compound optionally included. Owing to the differences between gas-phase-only reactions and heterogeneous catalysis, one of skill in the art would not apply the teaching of Arakawa to a reaction promoted by solid-phase catalytic particles, such as in Resaco. Such a gas-phase-only reaction is similarly very different to the subject matter recited in claim 1, which recites formation of aligned nano-structures on finely divided substrate particles. If anything, Arakawa, by requiring a homogeneous gas-phase reaction, teaches away from the invention as defined by claim 1, which combines a solid-phase catalytic material to react with a carbon containing gas. And once again, Arakawa neither teaches nor suggests the deposition methods set forth in claim 1 as amended. Accordingly, claim 1 is inventive over Arakawa and all the other claims, and accordingly all claims depending thereon are also patentable.

CONCLUSION

It follows from the above analysis that the references of record, considered independently or in proper combination, do not render unpatentable the subject matter of the present claims. The use of the methods of the present invention to produce aligned carbon nanostructures is an empirical finding that could not be predicted prior to the priority date of the present application. Accordingly, we respectfully request reconsideration and withdrawal of the examiner's objections.

Please charge any additional fee occasioned by this paper to our Deposit Account No. 07-1700.

Respectfully submitted,

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